



## P45000

### The Most Space-saving High-voltage Transducer for Rolling Stock

The P45000-series transducers are designed for measuring high DC and AC voltages on heavy vehicles, especially rolling stock. Application examples include the monitoring and control of traction motors or the monitoring of DC link voltage in traction power converters or on-board power converters.

The voltage measurement input is highly isolated from output and auxiliary power. The current output is compatible with commercially available control inputs.

The housing offers flexible mounting options: upright or horizontal, screwed or snapped onto 35 mm DIN rails. The devices can even be mounted in a stack, allowing for very tight space requirements.

For the first time, applications with functional safety requirements can be properly carried out. The high-voltage transmitter is certified for use in SIL2 systems and, redundantly, SIL3. Thus, for example, the presence of dangerously high voltages can be reliably detected.

#### Facts and Features

- For all DC- and AC-driven rolling stock, including diesel-electric vehicles
- Measurement up to 4500 V DC and 3000 V AC
- Test voltage: 20 kV AC
- Suitable for applications with functional safety up to SIL 2 / SIL 3.
- Reinforced insulation: up to 3700 V AC/ 4800 V DC
- Space-saving, especially with stacked mounting
- Flexibly adaptable to available space: vertical or horizontal mounting with screw fastening, alternatively DIN rail mounting
- Optional partition extends the clearance without additional space requirements and avoids "critical" mounting of the ring cable lugs
- Robust thanks to full vacuum encapsulation
- Certified for use on rolling stock according to EN 50155



# P45000

## Product Line

High-voltage transducer		P 4 5 [ ] [ ] [ ] K 2 [ ] [ ] [ ] [ ] / [ ] [ ] [ ] [ ]															
Type test voltage	10 kV	Nominal voltage $U_{in,n}$ [V]: 500, 750, 1000, 1500	0														
	20 kV	Nominal voltage $U_{in,n}$ [V]: 500, 750, 1000, 1500, 2000, 2800, 3000	1														
Current output $I_{out}$	$\pm 50$ mA; 3-wire connection, bipolar		0	0													
	10...50 mA; 3-wire connection, unipolar		1	1													
	4 ... 20 mA; 4-wire connection, unipolar*)		3														
	$\pm 20$ mA; 4-wire connection, bipolar*)		5	0													
	$\pm 10$ V; 4-wire connection, bipolar*)		6	0													
SIL 2/3	None		0														
	With		1														
Housing	Type							K	2								
	Wall mount only									0							
	Wall mount / 35-mm DIN rail									1							
HV connection	Screwed contact/ring cable lug									0							
	Potted cable									1							
Output/power supply	Push-in terminals										1						
	Screw terminals										2						
Input rated voltage	$U_{in,n} = \text{xxxx V}$												X	X	X	X	

## Accessories

Partition	To increase the clearances. Is installed near the input's high voltage contacts.	ZU1471
Jumper	For connection (parallel installation) of the input screw terminals of two devices. Is installed on the screwed contact.	ZU1474

\*) under development

### Standards and Directives

The devices were developed in compliance with the following standards and directives

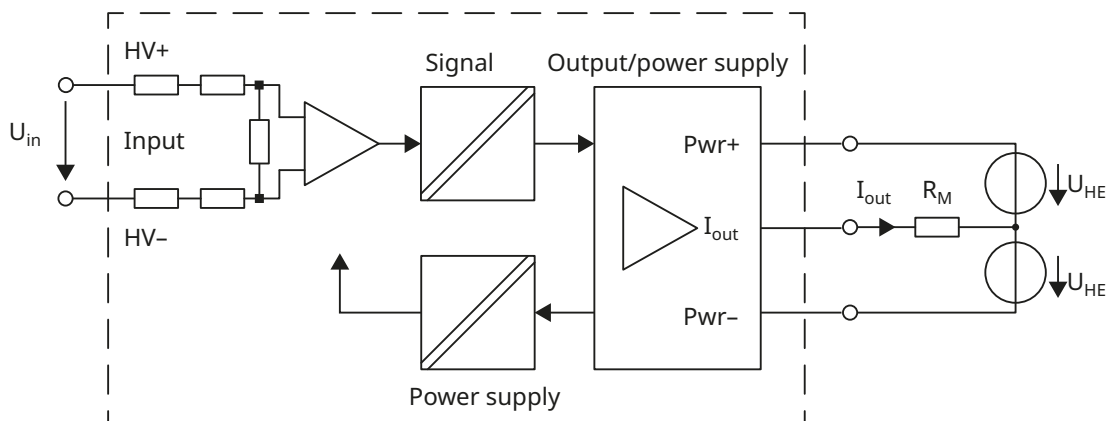
#### Directives

- Directive 2014/30/EU (EMC)
- Directive 2014/35/EU (Low voltage)
- Directive 2011/65/EU (RoHS)
- Directive 2012/19/EU (WEEE)
- Regulation (EC) No. 1907/2006 (REACH)

#### Standards

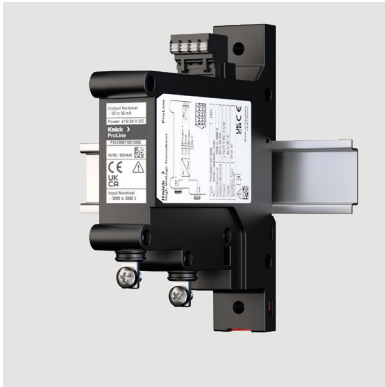
Rail applications	EN 50155, EN 50153, EN 50123-7-1, EN 50123-7-3
Resistance to vibration and shock	EN 61373, IEC 61373
Fire protection	EN 45545-1, EN 45545-2, EN 45545-5
EMC	EN 50121-1, EN 50121-3-2, EN 50121-5
Isolation requirements	EN 50124-1
Climate	EN 50125-1, EN 50125-3
Industrial applications	EN 61010-1
EMC	EN IEC 61326-1
Functional safety	EN IEC 61508
Isolation requirements	EN 50178, UL 347, EN 61010-1, EN IEC 60664-1
Restriction of Hazardous Substances/RoHS	EN IEC 63000

### Block Diagram

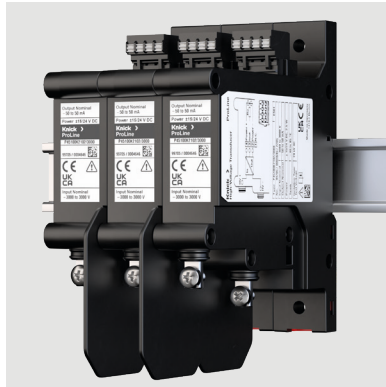


# P45000

## Installation



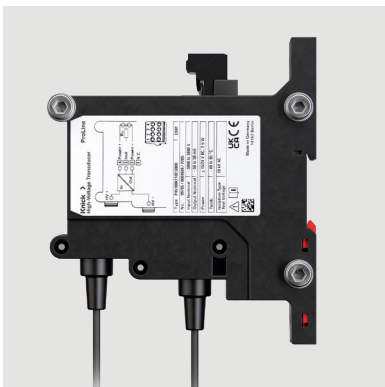
DIN rail mounting with screw terminals



DIN rail mounting with ZU1471 partitions



Vertical screw mounting with fixed cable



Horizontal screw mounting on non-conductive mounting surface



Vertical screw mounting on mounting surface



Screw mounting with ZU1474 input bridge

**Specifications**

<b>Input</b>		Measuring ranges/Output ranges			
Product variant	Rated voltage	Nominal measuring range	Nominal output range	Type test voltage	
<b>Product without SIL</b>					
P45000K2***/0500	500 V	±500 V	±50 mA	10 kV	
P45000K2***/0750	750 V	±750 V	±50 mA	10 kV	
P45000K2***/1000	1000 V	±1000 V	±50 mA	10 kV	
P45000K2***/1500	1500 V	±1500 V	±50 mA	10 kV	
P45100K2***/0500	500 V	±500 V	±50 mA	20 kV	
P45100K2***/0750	750 V	±750 V	±50 mA	20 kV	
P45100K2***/1000	1000 V	±1000 V	±50 mA	20 kV	
P45100K2***/1500	1500 V	±1500 V	±50 mA	20 kV	
P45100K2***/2000	2000 V	±2000 V	±50 mA	20 kV	
P45100K2***/2800	2800 V	±2800 V	±50 mA	20 kV	
P45100K2***/3000	3000 V	±3000 V	±50 mA	20 kV	
<b>Products with SIL/EN 61508</b>					
P45011K2***/0500	500 V	0 ... 500 V	10 ... 50 mA	10 kV	
P45011K2***/0750	750 V	0 ... 750 V	10 ... 50 mA	10 kV	
P45011K2***/1000	1000 V	0 ... 1000 V	10 ... 50 mA	10 kV	
P45011K2***/1500	1500 V	0 ... 1500 V	10 ... 50 mA	10 kV	
P45111K2***/0500	500 V	0 ... 500 V	10 ... 50 mA	20 kV	
P45111K2***/0750	750 V	0 ... 750 V	10 ... 50 mA	20 kV	
P45111K2***/1000	1000 V	0 ... 1000 V	10 ... 50 mA	20 kV	
P45111K2***/1500	1500 V	0 ... 1500 V	10 ... 50 mA	20 kV	
P45111K2***/2000	2000 V	0 ... 2000 V	10 ... 50 mA	20 kV	
P45111K2***/2800	2800 V	0 ... 2800 V	10 ... 50 mA	20 kV	
P45111K2***/3000	3000 V	0 ... 3000 V	10 ... 50 mA	20 kV	
Rated voltage according to EN 50163	$U_n = 600 \text{ V DC to } 3000 \text{ V DC}$				
Maximum measuring range	150 % of the nominal measuring range				
Maximum permissible crest factor	1.5 related to nominal measuring range				

# P45000

## Specifications

Thermal overload capacity	Input rated voltage	Permanent overvoltage	Short-term overvoltage (max. $R_{in}$ 1 s, peak value)	Input resistance
	±500 V	±750 V	±1500 V	2.7 MΩ
	±750 V	±1500 V	±3000 V	5.4 MΩ
	±1000 V	±1500 V	±3000 V	5.4 MΩ
	±1500 V	±3000 V	±6000 V	10 MΩ
	±2000 V	±3000 V	±6000 V	10 MΩ
	±2800 V	±4500 V	±9000 V	16.8 MΩ
	±3000 V	±4500 V	±9000 V	16.8 MΩ

Input capacitance < 10 pF

## Output

Output current in nominal measuring range	P45*0*K2***	$I_{out} = \pm 50$ mA
	P45*1*K2***	$I_{out} = 10 \dots 50$ mA
Maximum output current	P45*0*K2***	$I_{out,max} = \pm 75$ mA
	P45*1*K2***	$I_{out,max} = 70$ mA
Load	0 ... 200 Ω for $I_{out} = -50 \dots 50$ mA	
	0 ... 133 Ω for $I_{out} = -75 \dots 75$ mA	

## Device Error Detection and Signaling

Output current (error)	P45*0*K2***	no error signaling
	P45*1*K2***	$I_{out, failure} < 9$ mA

## Transmission Behavior

Gain error	< 0.2 % of measured value at 23 °C (73.4 °F)
Offset error	< 100 μA at 23 °C (73.4 °F)
Temperature influence	< 100 ppm/K full scale
Total error in the complete temperature range	< 1 % full scale
Ripple	≤ 10 mV <sub>rms</sub>
Cutoff frequency (-3 dB)	≥ 10 kHz
Response time	< 70 μs
$T_{90resp}$	
Readiness for operation (after switching on the power supply)	< 100 ms

**Specifications****Common-mode Rejection Ratio**

CMRR <sup>1)</sup>	> 150 dB (DC)
	> 90 dB (AC 16.7 Hz/50 Hz/60 Hz)
T-CMRR <sup>2)</sup>	> 70 dB
	Input square step: $T_r = 1 \mu\text{s}$

**Power Supply**

## Power supply

Nominal voltage  $\pm 15 \text{ V DC}, \pm 10 \% \dots \pm 24 \text{ V DC}, \pm 10 \% \text{ range}$

DC ripple upstream power supply  $\leq 100 \text{ mV}_{\text{p-p}}$

Short-term interruption/  
undervoltage

Interruption class of the power supply unit according to EN 50155 S1

Switchover class of the power supply unit according to EN 50155 According to upstream power supply

## Power consumption

0.8 W when supplied with  $\pm 15 \text{ V}$  and  $I_{\text{out}} = 0 \text{ mA}$   
 2.5 W when supplied with  $\pm 24 \text{ V}$  and  $I_{\text{out}} = \pm 50 \text{ mA}$   
 3.3 W when supplied with  $\pm 26.4 \text{ V}$  and  $I_{\text{out}} = \pm 75 \text{ mA}$

Inrush current per supply  
connection

$0.0001 \text{ A}^2\text{s} = 100 \mu\text{A}^2\text{s}$

## Reverse polarity protection

Reverse polarity protected

**Isolation**

## Galvanic isolation

Input against output/power supply  
2-port isolation

## Type test

Test voltage	P450**K2***	10 kV AC for 1 min
	P451**K2***	20 kV AC for 1 min
Surge voltage	P450**K2***	30 kV
	P451**K2***	50 kV

## Routine test

Test voltage	P450**K2***	10 kV AC for 10 s
	P451**K2***	16 kV AC for 10 s

## Freedom from partial discharge

Extinction voltage ( $< 10 \text{ pC}$ )  
 $\geq 10 \text{ kV AC (50 Hz)}$

## Overvoltage category

OV3

## Pollution degree

P45***K2***	PD2
P45***K2*1*	PD3A (EN 50124-1 only)

# P45000

## Specifications

Isolation of the variant with screwed contacts P45\*\*\*K2\*0\*

Rated isolation voltage  $U_{Nm}$

Reinforced insulation	P 450**K2*0*	
Input against output/power supply	EN 50124-1 (rolling stock)	2300 V AC/DC
	EN 50124-1 (stationary installations)	2300 V AC/DC
	EN 50178	2300 V AC/DC
	UL 347 <sup>3)</sup>	2300 V AC/DC
	EN IEC 60664-1	1000 V AC / 1500 V DC
	EN 61010-1	1000 V AC/DC
P451**K2*0*		
Input against output/power supply	EN 50124-1 (rolling stock)	3700 V AC/DC
	EN 50124-1 (stationary installations)	3600 V AC/DC
	EN 50178	3600 V AC/DC
	UL 347 <sup>3)</sup>	2500 V AC/DC
	EN IEC 60664-1	1000 V AC / 1500 V DC
	EN 61010-1	1000 V AC/DC

Isolation of the variant with captive cable P45\*\*\*K2\*1\*

Rated isolation voltage  $U_{Nm}$

Reinforced insulation	P450**K2*0*	
Input against output/power supply	EN 50124-1 (rolling stock)	2300 V AC/DC
	EN 50124-1 (stationary installations)	2300 V AC/DC
	EN 50178	2300 V AC/DC
	UL 347 <sup>3)</sup>	2300 V AC/DC
	EN IEC 60664-1	1000 V AC / 1500 V DC
	EN 61010-1	1000 V AC/DC
P451**K2*0*		
Input against output/power supply	EN 50124-1 (rolling stock)	3600 V AC / 4800 V DC
	EN 50124-1 (stationary installations)	3600 V AC / 4800 V DC
	EN 50178	3600 V AC / 4800 V DC
	UL 347 <sup>3)</sup>	3600 V AC / 4800 V DC
	EN IEC 60664-1	1000 V AC / 1500 V DC
	EN 61010-1	1000 V AC/DC



**Specifications**

Function isolation input against input	EN 50124-1 (rolling stock)	3600 V AC / 4800 V DC
	EN 50124-1 (stationary installations)	3600 V AC / 4800 V DC
	EN 50178	3600 V AC / 4800 V DC
	UL 347 <sup>3)</sup>	3600 V AC / 4800 V DC
	EN IEC 60664-1	1000 V AC / 1500 V DC
	EN 61010-1	1000 V AC/DC

Clearance and Creepage Distances

Clearances	P45***K2*0*	Between the inputs	Min. 36 mm (1.42")
		Between inputs and output/power supply	Min. 102 mm (4.02")
		Between inputs and fastening screw for installation	Min. 35 mm (1.38")
		Between inputs and DIN rail	Min. 62 mm (2.44")
		Between side by side devices without partition	Min. 14 mm (0.55")
		Between side-by-side devices with partition	Min. 33 mm (1.29")
		Between inputs and mounting plate with partition, horizontal on mounting plate	Min. 18 mm (0.71")

P45\*\*\*K2\*1\*  
 Dependent on remaining cable length.  
 Cable is potted in the device.

Creepage distances	P45***K2*0*	Between the inputs	Min. 56 mm (2.20")
		Between inputs and output/power supply	Min. 104 mm (4.09")
		Between inputs and fastening screw for installation	Min. 57 mm (2.24")
		Between inputs and DIN rail	Min. 64 mm (2.52")
		Between side by side devices without partition	Min. 64 mm (2.52")
		Between side-by-side devices with partition	Min. 64 mm (2.52")

P45\*\*\*K2\*1\*  
 No accessible, live/conductive parts on the device.  
 Cable is potted in the device. Dependent on remaining cable length.

# P45000

## Specifications

### Ambient Conditions

Installation site according to EN 50155	Enclosed control cabinet, Appendix C: 1 and 2
Height class	AX up to 2000 m above MSL (EN 50125) Reduced isolation data for heights > 2000...4000 m above MSL
Temperature class	OT4/ST1 (+ 15 °C (59 °F)/10 min.) (EN 50155)  TX (EN 50125-1)
Class of rapid temperature change	H1 (EN 50155)

### Permitted temperatures

#### Single operation

Air gap >15 mm (0.59")

OT4

for  $U_{HE}/I_{out}/R_M$ :

at $\pm 24$ V/75 mA DC/0 $\Omega$	-40 ... 75 °C (-40 ... 167 °F)
at $\pm 24$ V/75 mA DC/133 $\Omega$	-40 ... 85 °C (-40 ... 185 °F)
at $\pm 24$ V/50 mA <sub>rms</sub> /0 $\Omega$	-40 ... 85 °C (-40 ... 185 °F)
at $\pm 15$ V/75 mA DC/0 $\Omega$	-40 ... 85 °C (-40 ... 185 °F)

#### Side By Side Operation

Air gap <15 mm (0.59")

Max. 3 devices

for  $U_{HE}/I_{out}/R_M$ :

at $\pm 24$ V/75 mA DC/0 $\Omega$	-40 ... 55 °C (-40 ... 131 °F)
at $\pm 24$ V/50 mA <sub>rms</sub> /0 $\Omega$	-40 ... 65 °C (-40 ... 149 °F)
at $\pm 24$ V/75 mA DC/133 $\Omega$	-40 ... 70 °C (-40 ... 158 °F)
at $\pm 15$ V/75 mA DC/0 $\Omega$	-40 ... 75 °C (-40 ... 167 °F)
at $\pm 15$ V/50 mA <sub>rms</sub> /200 $\Omega$	-40 ... 85 °C (-40 ... 185 °F)

### Transport/storage

#### Relative humidity

-50 ... 90 °C (-58 ... 194 °F)

(operation, storage, transport)

Annual mean value	≤ 75 %
Continuous operation	15 ... 75 %
Continuously for 30 days a year	75 ... 95 %
Occasionally on the other days	95 ... 100 %

### Pollution degree

P45***K2***	PD2
P45***K2*1*	PD3A (EN 50124-1 only)

## Specifications

### Device

Weight	P45***K2*0*	Without partition	Approx. 370 g
		With partition	Approx. 390 g
	P45***K2*1*		Approx. 500 g
Screw tightening torques	M5 input terminals		3 Nm
	Output screw terminals		0.6 Nm
	Vertical on mounting plate 2 x M6		5 Nm
	Horizontal on mounting plate 3 x M6 (max. 3 devices stacked)		3 Nm

### Further Data

EMC	Rail applications	EN 50121-1, EN 50121-3-2, EN 50121-5	
	Industrial applications	EN 61326-1, EN 61326-3-1	
	Emitted interference	Class B	
	Immunity to interference	Industrial applications	
Mechanical load Shock and vibration	According to EN 61373, IEC 61373	Category 1, Class B, tested by independent test laboratory	
Fire protection	EN 45545-1, EN 45545-2, EN 45545-5		
	For exterior applications (combustible mass < 400 g) up to HL3		
	For interior applications: Mounting in closed and fire-protected control cabinets		
Functional safety	Certified by independent test laboratory		
	Type A device according to EN 61508		
	Interference immunity requirements for safety-related systems EN 61326-3-1:2017		
	Reinforced insulation between input and output		
	Test interval (proof test interval)	≤ 20 years	
	Service life	20 years, L4 according to EN 50155	
	Signal transmission within specifications		
	Single operation	SIL 2 (2 ) (HFT = 0)	
	Redundant operation (1oo2 configuration)	SIL 2 (SC 2), SIL 3 (SC 3) (HFT = 1)	
	Cutoff frequency of the low-pass filter provided	$f_{-3dB} \leq 200$ Hz	

# P45000

## Specifications

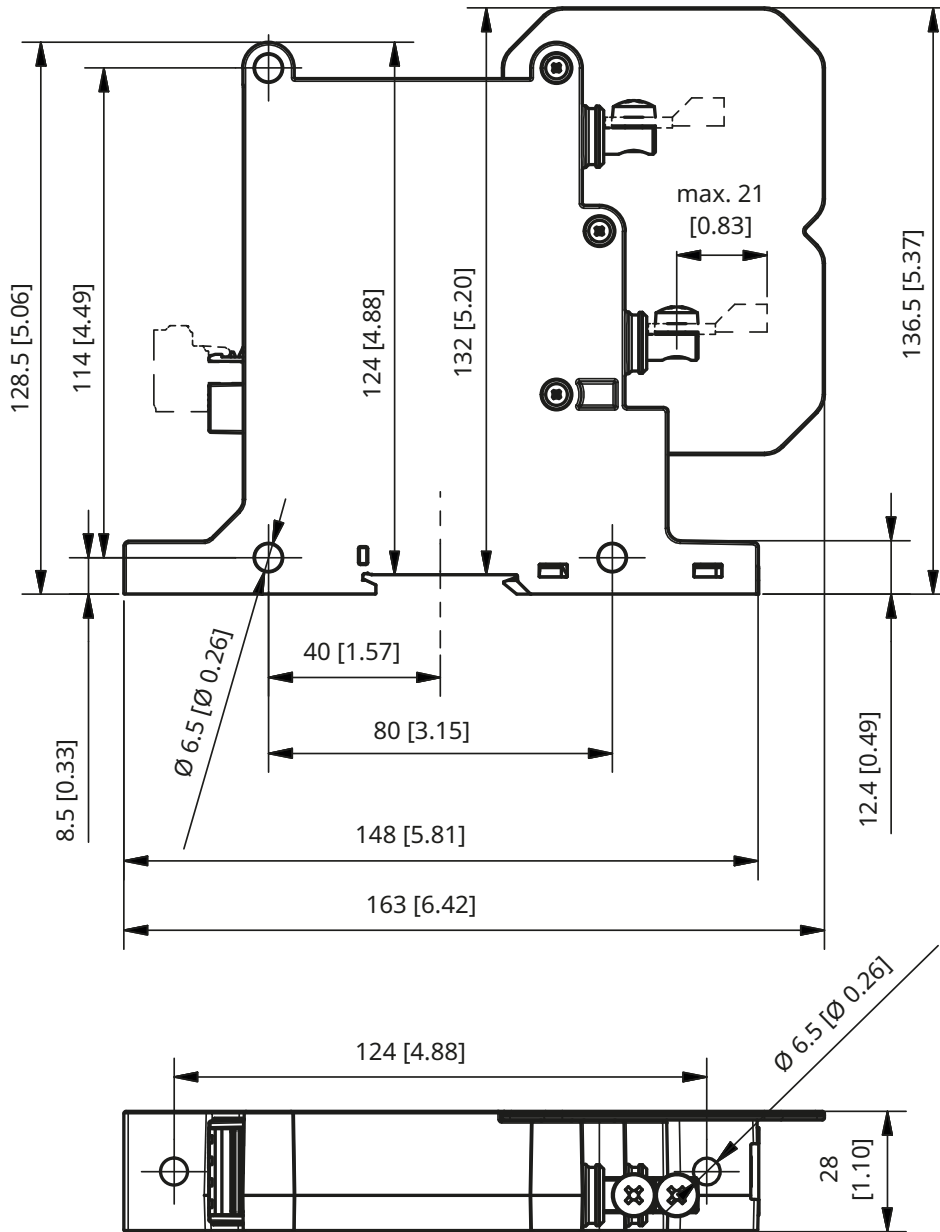
MTBF/MTTF according to EN 61709	Single operation	209 years	
	Side-by-side operation (group of 3 devices)	68 years	
	Requirements	Stationary operation in well-kept spaces No aeration Continuous operation 45 °C average ambient temperature	
Design	Surface mount housing, optionally with mounting on 35-mm DIN rail		
Contact protection		Input	
		Output/power supply	
	P45***K2*0*	IP00	IP20
	P45***K2*1*	IP54	IP20
Encapsulation	Electronics completely encapsulated by potting with a silicone-free polyurethane casting resin		
Hazardous substances	This product contains no hazardous substances according to the REACH Regulation (EC 1907/2006, 1688/2016). The restriction of hazardous substances according to the RoHS Directive (2011/65/EU) is complied with.		

1) Common-mode rejection ratio = differential voltage gain / common-mode voltage gain

2) Transient common-mode rejection ratio = differential DC gain / common-mode transient peak value gain

3) In approval

Dimension Drawing



All dimensions in mm [inches]

# P45000

## Terminal Assignments

---

